New Abrasive Bond Improves Ceramic Grinding Results

ENERGY EFFICIENCY AND RENEWABLE ENERGY

OFFICE OF TRANSPORTATION TECHNOLOGIES

Transportation

FOR THE 21ST CENTURY

Background

A recent breakthrough in grinding wheel technology has greatly improved the ceramic machining process, slashing the cost of finished parts and enabling wider use of advanced structural ceramics, like silicon nitride. In the past, from 30-70% of the cost of high-performance ceramic engine parts like valves, valve guides, injector plungers, and roller followers was attributed to machining and finishing operations. Advances over the last ten years in ceramic machining methods have cut those costs dramatically, and one of the most important of these is the Office of Transportation Technologies (OTT)-sponsored development of a new diamond wheel that is optimized for grinding ceramics.

A five-year cooperative project between OTT and the Norton Company (Worcester, Massachusetts) focused on improving the reliability and cost effectiveness of advanced ceramics grinding. With the support of the Ceramic Technology for Advanced Heat Engines Project at Oak Ridge National Laboratory, researchers used a systems approach to investigate the total interaction of all grinding wheel parameters and how they influence the thermal and mechanical conditions in the grinding zone. An improved understanding of grinding fundamentals has enabled the development of a new, metal-matrix binding system for the diamond abrasives that results in more efficient grinding wheels that last longer. An additional benefit is improved surface finish and reduced defects in the final part.

The Technology

For the grinding wheel to do its work, the adhesive bond must wear away at a controlled rate to expose new cutting edges as the working particles dull. In some cases, the bond is able to conduct heat away from the work area. The type of bond most widely used with diamond wheels is resin, a tough polymer designed to hold the diamond particles to the rim of the grinding wheel. While resin-bonded wheels remove material quickly, they have the disadvantage of wearing too quickly under the pressure of ceramics grinding. They also require frequent truing to hold their form. A stronger bond type is metal. Metal-bond wheels offer longer life than resin-bond products, and can be operated at the higher speeds used in ceramic grinding. However, conventional metal-bonded wheels require periodic dressing, a process that is difficult and time consuming.

The new metal-matrix bond developed under the joint OTT/Norton effort is designed to provide intermediate grinding action between standard resin and metal-bonded wheels. Wheels with the new bond require less force than resin wheels, cut more freely, and maintain the long product life typically associated with metal-bond products. They have the added advantage of achieving the finer finishes typically associated with resin-bonded wheels. In tests at Norton's Higgins Grinding Technology Center, the metal-matrix bond wheel showed substantial performance advantages over conventional products, including wheel wear, grinding speed, and material removal rate.

Commercialization

Norton Company, the world's leading supplier of bonded abrasives, has taken the lead in commercializing the new metal-matrix bonded grinding wheel. The new wheel is now being used extensively in the manufacture of components for the electronics industry, especially those composed of aluminum oxide, zirconium, aluminum nitrite, and chemical vapor deposition (CVD) silicon carbide.

Benefits

- **Finer finishes and better surface quality now possible at faster grinding rates**
- **All operations, from roughing to finishing, now possible with a single grinding wheel**
- **Longer wheel life and lower maintenance**
- **Greatly improved quality and lower failure rate for ceramic parts**

This metal-matrix bond wheel has substantial performance advantages over conventional grinding wheels.

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